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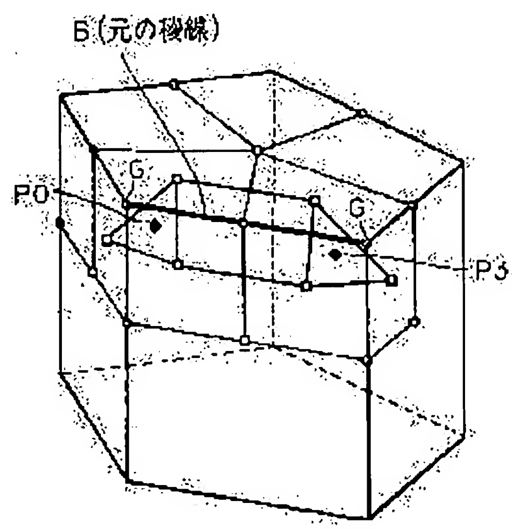
(54) METHOD FOR GENERATING CURVED-SURFACE MODEL BY REVERSIBLE ROUNDING-OFF OPERATION, METHOD FOR GENERATING LATTICE POLYGON MODEL FROM THE MODEL, RECORDING MEDIUM FOR EXECUTING THESE METHODS, AND METHOD FOR TRANSMITTING/DISPLAYING CURVED-SURFACE MODEL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide completely reversible rounding-off operation which can generate a stricter curved-surface model.

SOLUTION: The apex P0 of a curved-surface model corresponding to each apex G of a lattice polygon model is calculated. The coordinate values of the new apexes P0 are calculated by performing linear transformation on the coordinate values of the original apex group. Then the curved edge lines of the curved-surface model corresponding to the ridge lines B of the polygon model are decided. The curved ridge lines are expressed by cubic Bezier curves. In addition, a model surrounded by the Bezier curves is interpolated by using Gregory curved surfaces. Consequently, a curved-surface model having the same phase structure as that of the lattice polygon model is generated. In addition, the curved-surface model can also be generated similarly from a lattice model which is formed by giving arbitrary apexes and the rounded-off information on the ridge lines to the lattice polygon model.



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CLAIMS

[Claim(s)]
[Claim 1] The generation method of the curved-surface model by reversible rounding characterized by consisting of a step which computes the top-most vertices of the curved-surface model corresponding to this by linear transformation, and a step which computes the control point of a ridgeline with the 3rd Bezier curve of the curved-surface model corresponding to this to each ridgeline of a grid polygon model to each top-most vertices of a grid polygon model.
[Claim 2] The generation method of the curved-surface model by reversible rounding characterized by having the step which interpolates the model surrounded by said 3rd Bezier curve according to a Gregory curved surface in addition to a step according to claim 1.
[Claim 3] The step which has further the step which rounds off to said grid polygon model, and adds information in the generation method of the curved-surface model by reversible rounding according to claim 1 or 2, and computes the top-most vertices of said curved-surface model by linear transformation is the generation method of the curved-surface model by reversible rounding characterized by having a calculation step for said top-most vertices based on said rounding-off information.
[Claim 4] It is the generation method of the curved-surface model by reversible rounding characterized by said rounding-off information being the rounding-off information over the top-most vertices and/or the ridgeline of arbitration of said grid polygon model in the generation method of the curved-surface model by reversible rounding according to claim 3.
[Claim 5] The generation method of the grid polygon model by reverse rounding characterized by following a reverse step and generating said grid polygon model from the curved-surface model computed with the generation method of the curved-surface model by claim 1 thru/or reversible rounding given in any 1 of 4.
[Claim 6] The record medium which recorded the program for performing the generation method of the curved-surface model by reversible rounding given in claim 1 thru/or any 1 of 4, and/or the generation method of the grid polygon model by reverse rounding according to claim 5 and in which computer reading is possible.
[Claim 7] The transmission approach of the curved-surface model characterized by changing a curved-surface model into a grid polygon model by the approach indicated to claim 5, generating the data of the lattice structure which rounded off to this changed grid polygon model, and added information, and transmitting the data of this lattice structure according to the transmission demand of a curved-surface model.
[Claim 8] The method of presentation of the curved-surface model characterized by interpreting the data of the lattice structure transmitted by the approach indicated to claim 7, generating a curved-surface model from a grid polygon model by the approach indicated to claim 1 thru/or any 1 of 4, and displaying this curved-surface model.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] A record medium for this invention to perform the generation method, the grid polygon model generation methods from the curved-surface model, and those approaches of the curved-surface model by reversible rounding, and in transmission/method of presentation of a curved-surface model, and a twist detail It is related with the record medium for performing the generation method, the grid polygon model generation methods from the curved-surface model, and those approaches of the curved-surface model by rounding which had reversibility completely which can generate a stricter curved-surface model, and transmission/method of presentation of a curved-surface model.
[0002]
[Description of the Prior Art] The configuration which consists of a grid polygon model has the description of structure being simple and being easy to design it. Rounding occurs as the technique of generating a curved-surface model from this grid polygon model. If this is used, a curved-surface model can be easily transformed by transforming a grid polygon model. However, when a curved-surface model was generated conventionally, the technique of restoring this to a grid polygon model completely was not proposed. For this reason, once it generated the curved-surface model, it was not able to deform again only from this configuration using the grid polygon model.
[0003] In current and a network environment, the exchange of 3D data is not performed frequently. In VRML (Virtual Reality Modeling Language) which is standard 3 D transcription at the time of carrying out the network transfer of the three-dimension data, the set of the flat surface mainly called a polygon is expressing data. However, the more polygon structure tends to express data strictly, the more it has the fault that the amount of data becomes huge. By the data containing many especially curved-surface data, since many polygons were needed, the amount of data became large and had become the hindrance of the data transfer through a network. Moreover, there was also a problem that it could not raise in the DS sent by the polygon even if it can lower display precision. Thus, since little data which is high quality cannot express 3D data, the activity in the network of 3D data has been barred remarkably.
[0004] On the other hand, in the field of 3DCAD used by the manufacture, the technique expressing the solid model which had curved-surface data strictly is used, and such data representation has been supported by the format of the standard data exchange like IGES (Initial GraphicExchange Specification) or STEP (STandard for the Exchange of Productmodel data). In the world of CAD, in order to express the generated curved-surface configuration with high degree of accuracy, the strict configuration expression technique called a trim curved surface is used. Although these were suitable for the configuration expression with a very high precision, they were difficult for the amount of data to become large and to use by the network environment.
[0005]
[Problem(s) to be Solved by the Invention] It is (1) Japanese Patent Application No. No. 314697 [nine to] as the technique of reverse rounding-off like the former and ****.
(2) Research" about the free configuration deformation using "rounding
Generalization of the flexible curved-surface control by automatic generation of a Nakamura **** Keio

University graduate school policy and a media graduate course master's thesis, and a 1998.(3) "control grid" There was technique, such as Yuichiro Chagi, a Keio University graduate school policy and a media graduate course master's thesis, and 1998. However, it was not a perfect thing -- the field which constitutes all polygons from such technique must come on the same flat surface.
[0006] Moreover, it is Subdivision as another technique. There was also technique of Surface. This is the technique of subdividing a polygon model and generating a curved-surface model in false. Although this technique also has reversibility, this is the technique of generating the polygon model with which it was subdivided on the display to the last, and essentially differs from the technique of this invention which generates a strict curved-surface model.
[0007] Moreover, VRML which is a transcription on the conventional network was using the polygon as the base. Polygon data have the fault that the amount of data becomes large, when it is going to express a complicated configuration. Moreover, when little data tended to express the configuration, the expression capacity of a configuration fell and there was a problem that display quality will deteriorate.
[0008] It is computing each top-most vertices where this invention's was made in view of the actual condition like ****, and rounding by this invention generates a curved-surface model with the same phase structure (relation of the elements of a configuration) as a grid polygon model, and two models' correspond by linear transformation, respectively, and makes it possible to reverse-generate the original grid polygon model from the generated curved-surface model.
[0009] This invention is what generates the given grid polygon model and a curved-surface model with equivalent phase structure. As mentioned above, by this Each top-most vertices inside a grid polygon model and each top-most vertices inside a curved-surface model are made to correspond to 1 to 1. It enables it to mount reversible rounding by matching so that the corresponding coordinate value of each top-most vertices may be calculated by primary conversion, and generating the control point of the curve which constitutes a curved-surface model uniquely from top-most vertices which constitute the curved-surface model called for in this way.
[0010] As this invention is extended further, is rounded off to each grid polygon model and gives information, it enables it to generate the data of lattice structure also to the curved-surface model incorporated from the outside. This invention is expressing all configurations as interpolation curved-surface data, and expressing further according to the lattice structure which abstracted curved-surface structure, and makes it possible to express 3D configuration by the smaller amount of data. This invention sets the data of lattice structure to a server, is a high speed and enables it to interpret this lattice structure and to realize real 3D data transfer and its display as curved-surface data further, by putting the viewer which displays that curved-surface data with the detailed subdivided polygon model further on a client side.
[0011]
[Means for Solving the Problem] Invention of claim 1 is a method of generating the curved-surface model by reversible rounding characterized by consisting of following STEP1 and STEP2.
: (STEP1) The top-most vertices of the curved-surface model corresponding to this are computed to each top-most vertices of a grid polygon model. The coordinate value of these new top-most vertices is computed by the linear transformation of the coordinate value of the original top-most-vertices group.
: (STEP2) The curvilinear ridgeline of the curved-surface model corresponding to this is determined to each ridgeline of a grid polygon model. The 3rd Bezier curve expresses a ridgeline.
[0012] Invention of claim 2 is a method of generating the curved-surface model by reversible rounding which is further characterized by consisting of STEP3 in addition to invention of claim 1.
: (STEP3) The model surrounded by the 3rd Bezier curve is interpolated according to a Gregory curved surface (Gregory patch). The curved-surface model which had the same phase structure as a grid polygon model by this is generated.
[0013] The step which invention of claim 3 has further the step which rounds off to said grid polygon model, and adds information in the generation method of the curved-surface model by reversible rounding according to claim 1 or 2, and computes the top-most vertices of said curved-surface model by linear transformation is characterized by having a calculation step for said top-most vertices based on said rounding-off information.

[0014] Invention of claim 4 is characterized by said rounding-off information being the rounding-off information over the top-most vertices and/or the ridgeline of arbitration of said grid polygon model in the generation method of the curved-surface model by reversible rounding according to claim 3.
[0015] Invention of claim 5 is characterized by following a reverse step and generating said grid polygon model from the curved-surface model computed with the generation method of the curved-surface model by claim 1 thru/or reversible rounding given in any 1 of 4.
[0016] Invention of claim 6 is characterized by recording the program for performing the generation method of the curved-surface model by reversible rounding given in claim 1 thru/or any 1 of 4, and/or the generation method of the grid polygon model by reverse rounding according to claim 5.
[0017] Invention of claim 7 changes a curved-surface model into a grid polygon model by the approach indicated to claim 5, generates the data of the lattice structure which rounded off to this changed grid polygon model, and added information, and is characterized by transmitting the data of this lattice structure according to the transmission demand of a curved-surface model.
[0018] Invention of claim 8 interprets the data of the lattice structure transmitted by the approach indicated to claim 7, generates a curved-surface model from a grid polygon model by the approach indicated to claim 1 thru/or any 1 of 4, and is characterized by displaying this curved-surface model.
[0019]
[Embodiment of the Invention] Hereafter, the 1st configuration and principle of operation of an operation gestalt of this invention are explained. Drawing 13 is drawing showing the DS of the data used with the 1st operation gestalt of this invention. The top-most-vertices coordinate value table 200 (drawing 13 (A)) is a table holding the three-dimension coordinate value of the top-most vertices of the curved-surface model for which it asked by the three-dimension coordinate value (x y, z) of each top-most vertices of a polygon model (it is called a grid polygon model or a lattice polygon model), and the approach of STEP1 later mentioned to the top-most vertices of a grid polygon model. The field index table 300 (drawing 13 (B)) expresses the top-most vertices which constitute each polygon (it is called a grid polygon or a lattice polygon) of a grid polygon model as a train of the index value which shows a number of [the / of the top-most-vertices coordinate value table 200]. The size of a table is equal to the number of grid polygons. The ridgeline index table 400 (drawing 13 (C)) expresses each ridgeline of a grid polygon model and a curved-surface model with the pair (the starting point and terminal point) of top-most vertices, and holds the index value in the top-most-vertices coordinate value table 200 of those top-most vertices. The index value to the control point coordinate value table 500 (drawing 13 (D)) which has the coordinate of two control points (a control point 1 and control point 2) which appear when a straight-line ridgeline is changed into a 3rd Bezier curve in the case of a curved-surface model is added.
[0020] Drawing 10 is a block diagram showing the functional configuration of the 1st operation gestalt of this invention. The top-most-vertices calculation means 10 computes the top-most vertices of the curved-surface model corresponding to this to each top-most vertices of the grid polygon model referred to by the top-most-vertices coordinate value table 200 and the field index table 300. The coordinate value of these new top-most vertices is computed by the linear transformation of the coordinate value of the original top-most-vertices group. The coordinate value of the top-most vertices of the curved-surface model for which it asked here is stored in the applicable part of the top-most-vertices coordinate value table 200. The ridgeline decision means 20 determines the curvilinear ridgeline of the curved-surface model corresponding to this to each ridgeline of a grid polygon model with reference to three, the top-most-vertices coordinate value table 200, the field index table 300, and the ridgeline index table 400. Since the ridgeline of this curved-surface model is expressed by the 3rd Bezier curve, it stores the coordinate of the generated control point in the control point coordinate value table 500, and stores the index value to that table in the part to which the ridgeline index table 400 corresponds further. The curved-surface generation means 30 interpolates the curved-surface model surrounded by the 3rd Bezier curve according to a Gregory curved surface with reference to three, the top-most-vertices coordinate value table 200, the field index table 300, and the ridgeline index table 400. The curved-surface model which had the same phase structure as a grid polygon model by this is generated.

[0021] The coordinate value of the top-most vertices of the curved-surface model of the result of having changed and obtained the grid polygon model is computed in the form which carried out linear transformation of the coordinate value of the top-most vertices of the original grid polygon model. That is, the top-most vertices of the original grid polygon model are set to Vi, and the real number, then the location Pj of new top-most vertices can express ki in the form of a formula (1) (i= 1, 2 --n;j=1, and 2 --n;n is the number of top-most vertices). Moreover, inverse transformation can be defined as linear transformation. That is, top-most vertices Vi become computable by the formula (2).
[0022]
[Equation 1]

$$P_j = \sum_{i=1}^{n} k_{ij} V_i \qquad (j=1,2,\ldots,n) \qquad \text{式}(1)$$

$$V_i = \sum_{j=1}^{n} l_{ij} P_j \qquad (i=1,2,\ldots,n) \qquad \text{式}(2)$$

[0023] Therefore, the coordinate value of the top-most vertices of the original grid polygon model is conversely computable from the coordinate value of the top-most vertices of the curved-surface model of a result. If the configuration of the ridgeline between the computed top-most vertices is straight-line-ized, the original grid polygon model is generable. Consequently, reversible rounding can be realized. Furthermore, by transmitting this lightweight grid polygon data on a network, by performing this rounding by the client PC side which received that data, a curved-surface model is generated and it also becomes possible to display on a screen as a still more detailed polygon model.
[0024] Below, a grid polygon model as shows the flow of processing of this operation gestalt to drawing 1 based on drawing 11 is made into an example, and is explained at a detail.
[0025] (STEP1)
(I) All the fields A that constitute a grid polygon model (drawing 1) are divided into a quadrilateral. For this reason, it asks for the core C of all the fields A and the middle point D of Ridgeline B which constitute a polygon first (drawing 2). The core of a field is performed by calculating the average coordinate value of n top-most vertices Vi which constitute a field (if weighting may be carried out to each top-most vertices in this case and weighting is carried out, the location of Core C and the location of the middle point D will change). As shown in drawing 3 , quadrilateral division of Field A is performed by connecting the core C of each side to the middle point D of each ridgeline B, respectively.
(II) The core F of the quadrilateral side E is searched for by searching for the core F of the top-most vertices which constitute the generated four-side each form E (drawing 4). Here, calculation of Core F is performed by searching for the average coordinate of the top-most vertices which constitute a four-side each form (of course, weighting may be made top-most vertices also here).
(III) As shown in drawing 5 , an epilogue and a polygon H are generated for the core F of the four-side each form face which adjoins the original top-most vertices G. The core P0 of the top-most vertices which constitute this polygon H is searched for. Main calculation is performed also here by calculating the average coordinate value of the top-most vertices which constitute each polygon (in addition, weighting may be carried out also here). This core P0 serves as top-most vertices of the curved-surface model corresponding to the top-most vertices G of the original grid polygon model. A core P0 is the average coordinate of Point F, Point F is the average coordinate of Points C and D, and, moreover, Points C and D are the average coordinates of the top-most vertices of the original grid polygon model. Therefore, P0 is computable with the linear transformation of the top-most vertices of the original grid polygon model.
[0026] (STEP2)
(I) Vector P0Q which connects the called-for new top-most vertices P0 and the middle point Q of the ridgeline I of the generated polygon H is defined (drawing 6).
(II) A curved configuration is decided that the vector decided here serves as a tangent of the curvilinear ridgeline newly generated. The curvilinear configuration corresponding to the straight-line ridgeline B of

drawing 7 is searched for. A curve makes P0 and P3 an endpoint. Vector P3R which connects the called-for new top-most vertices P3 and the middle point R of the ridgeline of the generated polygon is defined similarly, and control points P1 and P2 are decided to become the relation of the following [drawing 8].
[0027]
[Equation 2]

$$P0P1 = \frac{4}{3} P0Q$$

$$P3P2 = \frac{4}{3} P3R$$

[0028] (III) Control points P0, P1, P2, and P3 are connected in order, and the 3rd Bezier curve corresponding to the original ridgeline B of drawing 7 is determined.
[0029] (STEP3)
(I) The curved-surface configuration surrounded by the 3rd Bezier curve as it was in the foundation of three dimensional CAD and application (KYORITSU SHUPPAN) can be interpolated by using a Gregory curved surface by well-known technique (Gregory patch). Thereby, a curved-surface configuration is determined and the configuration of a curved-surface model is decided.
[0030] (Example) The example of the curved-surface model which generated with the grid polygon model to drawing 9 (A), and was generated by this technique to drawing 9 (B) is shown. Since the grid polygon model of drawing 9 (A) and the curved-surface model of drawing 9 (B) support 1 to 1 in points, lines, and all the fields, they can generate the configuration of drawing 9 (A) by performing reverse rounding to the configuration of drawing 9 (B).
[0031] Furthermore, this invention was not limited only to the above-mentioned operation gestalt, and can be carried out also by computer configuration like drawing 12 . The input means 1 is constituted by a keyboard, a mouse, the touch panel, etc., and is used for an informational input. The output means 2 makes the information inputted from various print-outs and input means 1 output, and consists of a display, a printer, etc. CPU3 operates various programs. Memory 4 holds the information created temporarily, when the program itself is held and the program is performed by CPU3. The storage means 5 holds a program, data, temporary information at the time of program execution, etc. The medium driving gear 6 equips with the record medium which memorized a program, data, etc., reads them, and is used for storing in memory 4 or the storage means 5. Moreover, you may use for I/O or carrying out [of immediate data] program execution. In such a computer configuration, the same function as the operation gestalt of this invention is realizable by programming each function of each means shown in drawing 10 , writing in record media, such as CD-ROM, beforehand, equipping the computer carrying a CD-ROM drive with this CD-ROM, and loading that program to a computer. In addition, as a record medium, you may be any of semi-conductor media (for example, ROM, IC memory card, etc.), optical media (for example, DVD-ROM, MO and MD, CD-R, etc.), and magnetic media (for example, a magnetic tape, a flexible disk, etc.). Moreover, it the program which realizes the function of this invention is not only offered in the form of a medium, but may be offered by communication link.
[0032] Hereafter, the 2nd configuration and principle of operation of an operation gestalt of this invention are explained. Drawing 14 is drawing showing the outline of the 2nd operation gestalt of this invention. By this technique, in case a configuration is expressed, a high precision expresses a curved surface not using the polygon which approximated the original configuration roughly but using lattice structure (grid polygon model + rounding-off information). A network top transmits lightweight lattice structure. In addition to grids structure, although the curved-surface model was formed by rounding only from grids structure, the rounding-off information over the lattice point and/or the ridgeline of arbitration is added, and it transmits on a network and is made to perform rounding from the data or to perform rounding from the data on Client PC in this operation gestalt, with the 1st operation gestalt. The lattice kernel on PC which received the lattice structure transmitted at high speed interprets lattice structure, generates curved-surface data from here, and reproduces a real image by high-speed CPU by displaying on a screen using a detailed polygon model. By using lattice structure, little [extraordinarily] data enables it to send a real image with VRML. Here, this new format

is called XVL (eXtended VRML with Lattice). On the Internet, this XVL data is added on HTML or an XML file like the case of VRML data, and is referred to.
[0033] By expressing a configuration by using XVL according to (1) lattice structure (grid polygon model + rounding-off information) By expressing 3D configuration as lightweight data and giving the function (rounding-off function) changed into surface structure (curved-surface model) from lattice structure to (2) 3D modeling software as compared with subdivided polygon data and curved-surface data By having the function (reverse rounding-off function) to design a configuration with real surface structure easily, and to change (3) surface structures into lattice structure By connoting the function (rounding-off function) which makes easy conversion in the XVL format of the existing curved-surface data, and is changed into (4) viewer side from lattice structure at surface structure The lightweight XVL file which can be transmitted to a high speed is interpreted, and an expression and transfer with the description of making high-definition 3D display possible of 3D data are attained.
[0034] Drawing 15 is drawing for explaining mounting of the processing in this operation gestalt. If configuration data are actually processed using a XVL format of this invention, compared with a VRML format, it can express as XVL of the amount of data (in the case of the 1st operation gestalt; the case of the 2nd operation gestalt at most 4/3 time [in the case of the 1st operation gestalt] as many amount of data as this) of 1/several 10, and a network transfer of a high speed and real 3D data will be attained by carrying out the network transfer of this data. A server 41 has the XVL input device 51 used when inputting data in a XVL format, and the XVL inverter 52 which applies reverse rounding of this invention to the existing curved-surface data, and generates a XVL file, and distributes a XVL file through a network 42. On the other hand, a client 43 and PCs 44 has XVL expansion equipment 53 which performs rounding from lattice structure to Sir face structure. Still like a client PC 44, it constitutes so that it may have the XVL inverter 52 and the XVL input device 51, and it may be made to create the data of conversion of the existing curved-surface data or a new XVL format. Furthermore, each equipment may be software-ized and may be constituted.
[0035] (Transcription of XVL) Drawing 16 is drawing showing the DS of the configuration information by which endocyst is carried out to the XVL file in the 2nd operation gestalt of this invention. In addition, it is the same as that of the DS described with the 1st operation gestalt about the grid polygon model. Here, how to describe lattice structure (grid polygon model + more round information) to a file is explained. First, a grid polygon model can be expressed as usual polygon data (here, it is called grid polygon data). That is, it is expressed using the array of the coordinate value of the top-most vertices which constitute a grid polygon, and the top-most-vertices index array which specifies how they are connected and a grid polygon is constituted. At XVL, fine control of a curved-surface configuration is performed by rounding off to each top-most vertices and a ridgeline in addition to the information on a grid, and giving information. the index array (index of the top-most vertices of the both ends of a ridgeline) which specifies a ridgeline to the index with which such rounding-off information specifies top-most vertices to top-most vertices, the rounding-off multiplier of top-most vertices, and a ridgeline, the rounding-off multiplier of a ridgeline, a starting point rounding-off vector (vector which determines the direction of the tangent vector by the side of the starting point of a ridgeline), and a terminal point rounding-off vector (vector which determines the direction of the tangent vector by the side of the terminal point of a ridgeline) -- it is come out and constituted. Both indexes express the number on the coordinate value array of the top-most vertices which constitute grid polygon data.
[0036] The part corresponding to the top-most vertices and the ridgeline of a grid where the curved-surface configuration generated specified the rounding-off multiplier specifies how much it becomes close to a grid. If near of the rounding-off multiplier is carried out to 0, a curved-surface configuration will be generated so that it may become near the grid, and if a rounding-off multiplier is enlarged, it will become the greatly round configuration. The starting point / terminal point rounding-off vector of ridgeline rounding-off information are used, when reverse rounding-off is performed to a curved-surface model and grids structure is generated. These are the information for expressing a general 3rd Bezier curve with slight roundness, and serve to determine the tangent vector of curved starting point/terminal point. If a general geometric model is convertible for the curved-surface model which consists of only ridgelines which have a 3rd Bezier curve or a straight line in a geometric configuration, this can be described in a XVL format and the starting point /

terminal point rounding-off vector will be added to ridgeline rounding-off information in this case.
[0037] Below, a grid polygon model as shows the flow of processing of this operation gestalt to drawing 1 in the form added to explanation with the 1st operation gestalt is made into an example, and is explained at a detail. New top-most vertices are computed inside a quadrilateral side by searching for the core (average coordinate value of top-most vertices) of the top-most vertices which constitute the generated four-side each form from STEP1 in the 1st operation gestalt (II) (drawing 4). A rounding-off multiplier is a value to which the calculation approach of these new top-most vertices is changed. The new top-most vertices inside the four-side each form face at the time of specifying a rounding-off multiplier are computed by changing the value of u and v from a criterion on uv parameter flat surface in a four-side each form face, as shown in drawing 17 . In addition, u at the time of making a rounding-off multiplier into a certified value and v are set to 0.5.
[0038] For example, when the rounding-off multiplier of the original top-most vertices G is set as 0.2 (value lower than a certified value), parameter value of u of a four-side each form face and v is set to 0.2, respectively. Thereby, the top-most vertices of the curved-surface model created by STEP1 approach the top-most vertices of a corresponding grid model (grid polygon model), and the curved-surface model which sharpened rather than the case of a criterion and approached the grid polygon model is generated. Conversely, when the rounding-off multiplier of top-most vertices is set as a value higher than a certified value, a curved-surface model [far from a grid polygon model] roundish [wore more] is generated rather than the case of a criterion about the top-most vertices. moreover -- top-most vertices -- rounding-off -- a multiplier -- not but -- origin -- a ridgeline -- B -- rounding-off -- a multiplier (rounding-off multiplier of the middle point D of Ridgeline B) -- a certified value -- being low -- a value -- having set up -- a case -- **** -- a ridgeline -- B -- being concerned -- every -- four -- a side -- a form -- u -- ' -- v -- ' -- parameter value -- a low value -- carrying out . Thereby, the ridgeline of the curved-surface model created by STEP1 approaches the ridgeline B of a corresponding grid model (grid polygon model), and the curved-surface model which sharpened rather than the case of a criterion and approached the grid polygon model is generated. Conversely, when the rounding-off multiplier of a ridgeline is set as a value higher than a certified value, a curved-surface model [far from a grid polygon model] roundish [wore more] is generated rather than the case of a criterion about the ridgeline.
[0039] (Example) what showed the surface model generated with this operation gestalt to drawing 9 (B) to the lattice model of the origin which rounded off to the grid polygon model shown in drawing 9 (A), and added information -- top-most vertices and/or a ridgeline -- being related -- a radius of circle -- or it becomes the configuration where **** was given. The configuration of drawing 9 (A) is generated by performing reverse rounding to the configuration corresponding to this drawing 9 (B). Moreover, output data can be extremely lessened by expressing the configuration of drawing 9 (A) in a XVL format.
[0040] Drawing 18 is drawing showing human being's model expressed in the XVL format, and the example of the shading display. Since XVL expressed by drawing 18 (A) is a light weight (this example 44 K bytes), it can be easily transmitted also by the network environment. Moreover, the surface model was generated from this lattice model, and drawing 18 (B) indicated this by shading. If this structure is mounted as a viewer, XVL on a network can be read and real 3D display can be performed. Moreover, if a surface model is generated from the configuration in XVL and the data for RP (Rapid Prototyping) equipments are outputted, a real model is generable as shown in drawing 19 . Moreover, if the data for CAM are generated from a surface model, such a real model is also processible.
[0041]
[Effect of the Invention] Since he is trying to generate the curved-surface model corresponding to 1 to 1 to the original polygon in points, lines, and all the fields according to this invention so that clearly from the above explanation, rounding which had reversibility completely is realizable. Since a polygon model and a curved-surface model have the same phase, the attribute given to the original polygon model is inheritable. That is, it is possible to make a curved-surface model inherit the attribute of the color and texture which were given to the grid polygon model. This is a merit with difficult implementation by the conventional approach.
[0042] There is a merit that a configuration expression is possible, by the small amount of data, holding the

high data of quality, since the lattice structure of connoting surface structure is held according to the XVL format of this invention.
[0043] According to XVL of this invention, a certain amount of precision is maintained by expressing curved-surface information using the interpolation curved surface defined according to lattice structure (grid information + rounding-off information), realizing lightweight-ization of data. Since there is little amount of data, it can use by the network environment, and since the data representation as a curved surface is also possible, it has the merit [data / XVL] of being available, also by CAD/CAM.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention is that of generating the record medium for performing the generation method, the grid polygon model generation methods from the curved-surface model, and those approaches of the curved-surface model by reversible rounding and transmission/method of presentation of a curved-surface model, and the more stricter curved-surface model in a detail. It is related with the record medium for performing the generation method, the grid polygon model generation methods from the curved-surface model, and those approaches of the curved-surface model by rounding which had reversibility completely to cut, and transmission/method of presentation of a curved-surface model.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The configuration which consists of a grid polygon model has the description of structure being simple and being easy to design it. Rounding occurs as the technique of generating a curved-surface model from this grid polygon model. If this is used, a curved-surface model can be easily transformed by transforming a grid polygon model. However, when a curved-surface model was generated conventionally, the technique of restoring this to a grid polygon model completely was not proposed. For this reason, once it generated the curved-surface model, it was not able to deform again only from this configuration using the grid polygon model.
[0003] In current and a network environment, the exchange of 3D data is not performed frequently. In VRML (Virtual Reality Modeling Language) which is standard 3 D transcription at the time of carrying out the network transfer of the three-dimension data, the set of the flat surface mainly called a polygon is expressing data. However, the more polygon structure tends to express data strictly, the more it has the fault that the amount of data becomes huge. By the data containing many especially curved-surface data, since many polygons were needed, the amount of data became large and had become the hindrance of the data transfer through a network. Moreover, there was also a problem that it could not raise in the DS sent by the polygon even if it can lower display precision. Thus, since little data which is high quality cannot express 3D data, the activity in the network of 3D data has been barred remarkably.
[0004] On the other hand, in the field of 3DCAD used by the manufacture, the technique expressing the solid model which had curved-surface data strictly is used, and such data representation has been supported by the format of the standard data exchange like IGES (Initial GraphicExchange Specification) or STEP (STandard for the Exchange of Productmodel data). In the world of CAD, in order to express the generated curved-surface configuration with high degree of accuracy, the strict configuration expression technique called a trim curved surface is used. Although these were suitable for the configuration expression with a very high precision, they were difficult for the amount of data to become large and to use by the network environment.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since he is trying to generate the curved-surface model corresponding to 1 to 1 to the original polygon in points, lines, and all the fields according to this invention so that clearly from the above explanation, rounding which had reversibility completely is realizable. Since a polygon model and a curved-surface model have the same phase, the attribute given to the original polygon model is inheritable. That is, it is possible to make a curved-surface model inherit the attribute of the color and texture which were given to the grid polygon model. This is a merit with difficult implementation by the conventional approach.
[0042] There is a merit that a configuration expression is possible, by the small amount of data, holding the high data of quality, since the lattice structure of connoting surface structure is held according to the XVL format of this invention.
[0043] According to XVL of this invention, a certain amount of precision is maintained by expressing curved-surface information using the interpolation curved surface defined according to lattice structure (grid information + rounding-off information), realizing lightweight-ization of data. Since there is little amount of data, it can use by the network environment, and since the data representation as a curved surface is also possible, it has the merit [data / XVL] of being available, also by CAD/CAM.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] It is (1) Japanese Patent Application No. No. 314697 [nine to] as the technique of reverse rounding-off like the former and ****.
(2) Research" about the free configuration deformation using "rounding
Generalization of the flexible curved-surface control by automatic generation of a Nakamura **** Keio University graduate school policy and a media graduate course master's thesis, and a 1998.(3) "control grid" There was technique, such as Yuichiro Chagi, a Keio University graduate school policy and a media graduate course master's thesis, and 1998. However, it was not a perfect thing -- the field which constitutes all polygons from such technique must come on the same flat surface.
[0006] Moreover, it is Subdivision as another technique. There was also technique of Surface. This is the technique of subdividing a polygon model and generating a curved-surface model in false. Although this technique also has reversibility, this is the technique of generating the polygon model with which it was subdivided on the display to the last, and essentially differs from the technique of this invention which generates a strict curved-surface model.
[0007] Moreover, VRML which is a transcription on the conventional network was using the polygon as the base. Polygon data have the fault that the amount of data becomes large, when it is going to express a complicated configuration. Moreover, when little data tended to express the configuration, the expression capacity of a configuration fell and there was a problem that display quality will deteriorate.
[0008] It is computing each top-most vertices where this invention's was made in view of the actual condition like ****, and rounding by this invention generates a curved-surface model with the same phase structure (relation of the elements of a configuration) as a grid polygon model, and two models' correspond by linear transformation, respectively, and makes it possible to reverse-generate the original grid polygon model from the generated curved-surface model.
[0009] This invention is what generates the given grid polygon model and a curved-surface model with equivalent phase structure. As mentioned above, by this Each top-most vertices inside a grid polygon model and each top-most vertices inside a curved-surface model are made to correspond to 1 to 1. It enables it to mount reversible rounding by matching so that the corresponding coordinate value of each top-most vertices may be calculated by primary conversion, and generating the control point of the curve which constitutes a curved-surface model uniquely from top-most vertices which constitute the curved-surface model called for in this way.
[0010] As this invention is extended further, is rounded off to each grid polygon model and gives information, it enables it to generate the data of lattice structure also to the curved-surface model incorporated from the outside. This invention is expressing all configurations as interpolation curved-surface data, and expressing further according to the lattice structure which abstracted curved-surface structure, and makes it possible to express 3D configuration by the smaller amount of data. This invention sets the data of lattice structure to a server, is a high speed and enables it to interpret this lattice structure and to realize real 3D data transfer and its display as curved-surface data further, by putting the viewer which displays that curved-surface data with the detailed subdivided polygon model further on a client side.
[0011]

[Translation done.]

MEANS

[Means for Solving the Problem] Invention of claim 1 is a method of generating the curved-surface model by reversible rounding characterized by consisting of following STEP1 and STEP2.
: (STEP1) The top-most vertices of the curved-surface model corresponding to this are computed to each top-most vertices of a grid polygon model. The coordinate value of these new top-most vertices is computed by the linear transformation of the coordinate value of the original top-most-vertices group.
: (STEP2) The curvilinear ridgeline of the curved-surface model corresponding to this is determined to each ridgeline of a grid polygon model. The 3rd Bezier curve expresses a ridgeline.
[0012] Invention of claim 2 is a method of generating the curved-surface model by reversible rounding which is further characterized by consisting of STEP3 in addition to invention of claim 1.
: (STEP3) The model surrounded by the 3rd Bezier curve is interpolated according to a Gregory curved surface (Gregory patch). The curved-surface model which had the same phase structure as a grid polygon model by this is generated.
[0013] The step which invention of claim 3 has further the step which rounds off to said grid polygon model, and adds information in the generation method of the curved-surface model by reversible rounding according to claim 1 or 2, and computes the top-most vertices of said curved-surface model by linear transformation is characterized by having a calculation step for said top-most vertices based on said rounding-off information.
[0014] Invention of claim 4 is characterized by said rounding-off information being the rounding-off information over the top-most vertices and/or the ridgeline of arbitration of said grid polygon model in the generation method of the curved-surface model by reversible rounding according to claim 3.
[0015] Invention of claim 5 is characterized by following a reverse step and generating said grid polygon model from the curved-surface model computed with the generation method of the curved-surface model by claim 1 thru/or reversible rounding given in any 1 of 4.
[0016] Invention of claim 6 is characterized by recording the program for performing the generation method of the curved-surface model by reversible rounding given in claim 1 thru/or any 1 of 4, and/or the generation method of the grid polygon model by reverse rounding according to claim 5.
[0017] Invention of claim 7 changes a curved-surface model into a grid polygon model by the approach indicated to claim 5, generates the data of the lattice structure which rounded off to this changed grid polygon model, and added information, and is characterized by transmitting the data of this lattice structure according to the transmission demand of a curved-surface model.
[0018] Invention of claim 8 interprets the data of the lattice structure transmitted by the approach indicated to claim 7, generates a curved-surface model from a grid polygon model by the approach indicated to claim 1 thru/or any 1 of 4, and is characterized by displaying this curved-surface model.
[0019]
[Embodiment of the Invention] Hereafter, the 1st configuration and principle of operation of an operation gestalt of this invention are explained. Drawing 13 is drawing showing the DS of the data used with the 1st operation gestalt of this invention. The top-most-vertices coordinate value table 200 (drawing 13 (A)) is a table holding the three-dimension coordinate value of the top-most vertices of the curved-surface model for which it asked by the three-dimension coordinate value (x y, z) of each top-most vertices of a polygon model

(it is called a grid polygon model or a lattice polygon model), and the approach of STEP1 later mentioned to the top-most vertices of a grid polygon model. The field index table 300 (drawing 13 (B)) expresses the top-most vertices which constitute each polygon (it is called a grid polygon or a lattice polygon) of a grid polygon model as a train of the index value which shows a number of [the / of the top-most-vertices coordinate value table 200]. The size of a table is equal to the number of grid polygons. The ridgeline index table 400 (drawing 13 (C)) expresses each ridgeline of a grid polygon model and a curved-surface model with the pair (the starting point and terminal point) of top-most vertices, and holds the index value in the top-most-vertices coordinate value table 200 of those top-most vertices. The index value to the control point coordinate value table 500 (drawing 13 (D)) which has the coordinate of two control points (a control point 1 and control point 2) which appear when a straight-line ridgeline is changed into a 3rd Bezier curve in the case of a curved-surface model is added.

[0020] Drawing 10 is a block diagram showing the functional configuration of the 1st operation gestalt of this invention. The top-most-vertices calculation means 10 computes the top-most vertices of the curved-surface model corresponding to this to each top-most vertices of the grid polygon model referred to by the top-most-vertices coordinate value table 200 and the field index table 300. The coordinate value of these new top-most vertices is computed by the linear transformation of the coordinate value of the original top-most-vertices group. The coordinate value of the top-most vertices of the curved-surface model for which it asked here is stored in the applicable part of the top-most-vertices coordinate value table 200. The ridgeline decision means 20 determines the curvilinear ridgeline of the curved-surface model corresponding to this to each ridgeline of a grid polygon model with reference to three, the top-most-vertices coordinate value table 200, the field index table 300, and the ridgeline index table 400. Since the ridgeline of this curved-surface model is expressed by the 3rd Bezier curve, it stores the coordinate of the generated control point in the control point coordinate value table 500, and stores the index value to that table in the part to which the ridgeline index table 400 corresponds further. The curved-surface generation means 30 interpolates the curved-surface model surrounded by the 3rd Bezier curve according to a Gregory curved surface with reference to three, the top-most-vertices coordinate value table 200, the field index table 300, and the ridgeline index table 400. The curved-surface model which had the same phase structure as a grid polygon model by this is generated.

[0021] The coordinate value of the top-most vertices of the curved-surface model of the result of having changed and obtained the grid polygon model is computed in the form which carried out linear transformation of the coordinate value of the top-most vertices of the original grid polygon model. That is, the top-most vertices of the original grid polygon model are set to Vi, and the real number, then the location Pj of new top-most vertices can express ki in the form of a formula (1) (i= 1, 2 --n;j=1, and 2 --n;n is the number of top-most vertices). Moreover, inverse transformation can be defined as linear transformation. That is, top-most vertices Vi become computable by the formula (2).

[0022]

[Equation 1]

$$P_j = \sum_{i=1}^{n} k_{ij} V_i \qquad (j=1,2,\ldots,n) \qquad 式(1)$$

$$V_i = \sum_{j=1}^{n} l_{ij} P_j \qquad (i=1,2,\ldots,n) \qquad 式(2)$$

[0023] Therefore, the coordinate value of the top-most vertices of the original grid polygon model is conversely computable from the coordinate value of the top-most vertices of the curved-surface model of a result. If the configuration of the ridgeline between the computed top-most vertices is straight-line-ized, the original grid polygon model is generable. Consequently, reversible rounding can be realized. Furthermore, by transmitting this lightweight grid polygon data on a network, by performing this rounding by the client PC side which received that data, a curved-surface model is generated and it also becomes possible to display on a screen as a still more detailed polygon model.

[0024] Below, a grid polygon model as shows the flow of processing of this operation gestalt to drawing 1 based on drawing 11 is made into an example, and is explained at a detail.
[0025] (STEP1)
(I) All the fields A that constitute a grid polygon model (drawing 1) are divided into a quadrilateral. For this reason, it asks for the core C of all the fields A and the middle point D of Ridgeline B which constitute a polygon first (drawing 2). The core of a field is performed by calculating the average coordinate value of n top-most vertices Vi which constitute a field (if weighting may be carried out to each top-most vertices in this case and weighting is carried out, the location of Core C and the location of the middle point D will change). As shown in drawing 3 , quadrilateral division of Field A is performed by connecting the core C of each side to the middle point D of each ridgeline B, respectively.
(II) The core F of the quadrilateral side E is searched for by searching for the core F of the top-most vertices which constitute the generated four-side each form E (drawing 4). Here, calculation of Core F is performed by searching for the average coordinate of the top-most vertices which constitute a four-side each form (of course, weighting may be made top-most vertices also here).
(III) As shown in drawing 5 , an epilogue and a polygon H are generated for the core F of the four-side each form face which adjoins the original top-most vertices G. The core P0 of the top-most vertices which constitute this polygon H is searched for. Main calculation is performed also here by calculating the average coordinate value of the top-most vertices which constitute each polygon (in addition, weighting may be carried out also here). This core P0 serves as top-most vertices of the curved-surface model corresponding to the top-most vertices G of the original grid polygon model. A core P0 is the average coordinate of Point F, Point F is the average coordinate of Points C and D, and, moreover, Points C and D are the average coordinates of the top-most vertices of the original grid polygon model. Therefore, P0 is computable with the linear transformation of the top-most vertices of the original grid polygon model.
[0026] (STEP2)
(I) Vector P0Q which connects the called-for new top-most vertices P0 and the middle point Q of the ridgeline I of the generated polygon H is defined (drawing 6).
(II) A curved configuration is decided that the vector decided here serves as a tangent of the curvilinear ridgeline newly generated. The curvilinear configuration corresponding to the straight-line ridgeline B of drawing 7 is searched for. A curve makes P0 and P3 an endpoint. Vector P3R which connects the called-for new top-most vertices P3 and the middle point R of the ridgeline of the generated polygon is defined similarly, and control points P1 and P2 are decided to become the relation of the following [drawing 8].
[0027]
[Equation 2]

$$P0P1 = \frac{4}{3}P0Q$$

$$P3P2 = \frac{4}{3}P3R$$

[0028] (III) Control points P0, P1, P2, and P3 are connected in order, and the 3rd Bezier curve corresponding to the original ridgeline B of drawing 7 is determined.
[0029] (STEP3)
(I) The curved-surface configuration surrounded by the 3rd Bezier curve as it was in the foundation of three dimensional CAD and application (KYORITSU SHUPPAN) can be interpolated by using a Gregory curved surface by well-known technique (Gregory patch). Thereby, a curved-surface configuration is determined and the configuration of a curved-surface model is decided.
[0030] (Example) The example of the curved-surface model which generated with the grid polygon model to drawing 9 (A), and was generated by this technique to drawing 9 (B) is shown. Since the grid polygon model of drawing 9 (A) and the curved-surface model of drawing 9 (B) support 1 to 1 in points, lines, and all the fields, they can generate the configuration of drawing 9 (A) by performing reverse rounding to the configuration of drawing 9 (B).

[0031] Furthermore, this invention was not limited only to the above-mentioned operation gestalt, and can be carried out also by computer configuration like drawing 12 . The input means 1 is constituted by a keyboard, a mouse, the touch panel, etc., and is used for an informational input. The output means 2 makes the information inputted from various print-outs and input means 1 output, and consists of a display, a printer, etc. CPU3 operates various programs. Memory 4 holds the information created temporarily, when the program itself is held and the program is performed by CPU3. The storage means 5 holds a program, data, temporary information at the time of program execution, etc. The medium driving gear 6 equips with the record medium which memorized a program, data, etc., reads them, and is used for storing in memory 4 or the storage means 5. Moreover, you may use for I/O or carrying out [of immediate data] program execution. In such a computer configuration, the same function as the operation gestalt of this invention is realizable by programming each function of each means shown in drawing 10 , writing in record media, such as CD-ROM, beforehand, equipping the computer carrying a CD-ROM drive with this CD-ROM, and loading that program to a computer. In addition, as a record medium, you may be any of semi-conductor media (for example, ROM, IC memory card, etc.), optical media (for example, DVD-ROM, MO and MD, CD-R, etc.), and magnetic media (for example, a magnetic tape, a flexible disk, etc.). Moreover, it the program which realizes the function of this invention is not only offered in the form of a medium, but may be offered by communication link.

[0032] Hereafter, the 2nd configuration and principle of operation of an operation gestalt of this invention are explained. Drawing 14 is drawing showing the outline of the 2nd operation gestalt of this invention. By this technique, in case a configuration is expressed, a high precision expresses a curved surface not using the polygon which approximated the original configuration roughly but using lattice structure (grid polygon model + rounding-off information). A network top transmits lightweight lattice structure. In addition to grids structure, although the curved-surface model was formed by rounding only from grids structure, the rounding-off information over the lattice point and/or the ridgeline of arbitration is added, and it transmits on a network and is made to perform rounding from the data or to perform rounding from the data on Client PC in this operation gestalt, with the 1st operation gestalt. The lattice kernel on PC which received the lattice structure transmitted at high speed interprets lattice structure, generates curved-surface data from here, and reproduces a real image by high-speed CPU by displaying on a screen using a detailed polygon model. By using lattice structure, little [extraordinarily] data enables it to send a real image with VRML. Here, this new format is called XVL (eXtended VRML with Lattice). On the Internet, this XVL data is added on HTML or an XML file like the case of VRML data, and is referred to.

[0033] By expressing a configuration by using XVL according to (1) lattice structure (grid polygon model + rounding-off information) By expressing 3D configuration as lightweight data and giving the function (rounding-off function) changed into surface structure (curved-surface model) from lattice structure to (2) 3D modeling software as compared with subdivided polygon data and curved-surface data By having the function (reverse rounding-off function) to design a configuration with real surface structure easily, and to change (3) surface structures into lattice structure By connoting the function (rounding-off function) which makes easy conversion in the XVL format of the existing curved-surface data, and is changed into (4) viewer side from lattice structure at surface structure The lightweight XVL file which can be transmitted to a high speed is interpreted, and an expression and transfer with the description of making high-definition 3D display possible of 3D data are attained.

[0034] Drawing 15 is drawing for explaining mounting of the processing in this operation gestalt. If configuration data are actually processed using a XVL format of this invention, compared with a VRML format, it can express as XVL of the amount of data (in the case of the 1st operation gestalt; the case of the 2nd operation gestalt at most 4/3 time [in the case of the 1st operation gestalt] as many amount of data as this) of 1/several 10, and a network transfer of a high speed and real 3D data will be attained by carrying out the network transfer of this data. A server 41 has the XVL input device 51 used when inputting data in a XVL format, and the XVL inverter 52 which applies reverse rounding of this invention to the existing curved-surface data, and generates a XVL file, and distributes a XVL file through a network 42. On the other hand, a client 43 and PCs 44 has XVL expansion equipment 53 which performs rounding from lattice structure to Sir face structure. Still like a client PC 44, it constitutes so that it may have the XVL inverter 52 and the XVL

input device 51, and it may be made to create the data of conversion of the existing curved-surface data or a new XVL format. Furthermore, each equipment may be software-ized and may be constituted.

[0035] (Transcription of XVL) Drawing 16 is drawing showing the DS of the configuration information by which endocyst is carried out to the XVL file in the 2nd operation gestalt of this invention. In addition, it is the same as that of the DS described with the 1st operation gestalt about the grid polygon model. Here, how to describe lattice structure (grid polygon model + more round information) to a file is explained. First, a grid polygon model can be expressed as usual polygon data (here, it is called grid polygon data). That is, it is expressed using the array of the coordinate value of the top-most vertices which constitute a grid polygon, and the top-most-vertices index array which specifies how they are connected and a grid polygon is constituted. At XVL, fine control of a curved-surface configuration is performed by rounding off to each top-most vertices and a ridgeline in addition to the information on a grid, and giving information. the index array (index of the top-most vertices of the both ends of a ridgeline) which specifies a ridgeline to the index with which such rounding-off information specifies top-most vertices to top-most vertices, the rounding-off multiplier of top-most vertices, and a ridgeline, the rounding-off multiplier of a ridgeline, a starting point rounding-off vector (vector which determines the direction of the tangent vector by the side of the starting point of a ridgeline), and a terminal point rounding-off vector (vector which determines the direction of the tangent vector by the side of the terminal point of a ridgeline) -- it is come out and constituted. Both indexes express the number on the coordinate value array of the top-most vertices which constitute grid polygon data.

[0036] The part corresponding to the top-most vertices and the ridgeline of a grid where the curved-surface configuration generated specified the rounding-off multiplier specifies how much it becomes close to a grid. If near of the rounding-off multiplier is carried out to 0, a curved-surface configuration will be generated so that it may become near the grid, and if a rounding-off multiplier is enlarged, it will become the greatly round configuration. The starting point / terminal point rounding-off vector of ridgeline rounding-off information are used, when reverse rounding-off is performed to a curved-surface model and grids structure is generated. These are the information for expressing a general 3rd Bezier curve with slight roundness, and serve to determine the tangent vector of curved starting point/terminal point. If a general geometric model is convertible for the curved-surface model which consists of only ridgelines which have a 3rd Bezier curve or a straight line in a geometric configuration, this can be described in a XVL format and the starting point / terminal point rounding-off vector will be added to ridgeline rounding-off information in this case.

[0037] Below, a grid polygon model as shows the flow of processing of this operation gestalt to drawing 1 in the form added to explanation with the 1st operation gestalt is made into an example, and is explained at a detail. New top-most vertices are computed inside a quadrilateral side by searching for the core (average coordinate value of top-most vertices) of the top-most vertices which constitute the generated four-side each form from STEP1 in the 1st operation gestalt (II) (drawing 4). A rounding-off multiplier is a value to which the calculation approach of these new top-most vertices is changed. The new top-most vertices inside the four-side each form face at the time of specifying a rounding-off multiplier are computed by changing the value of u and v from a criterion on uv parameter flat surface in a four-side each form face, as shown in drawing 17 . In addition, u at the time of making a rounding-off multiplier into a certified value and v are set to 0.5.

[0038] For example, when the rounding-off multiplier of the original top-most vertices G is set as 0.2 (value lower than a certified value), parameter value of u of a four-side each form face and v is set to 0.2, respectively. Thereby, the top-most vertices of the curved-surface model created by STEP1 approach the top-most vertices of a corresponding grid model (grid polygon model), and the curved-surface model which sharpened rather than the case of a criterion and approached the grid polygon model is generated. Conversely, when the rounding-off multiplier of top-most vertices is set as a value higher than a certified value, a curved-surface model [far from a grid polygon model] roundish [wore more] is generated rather than the case of a criterion about the top-most vertices. moreover -- top-most vertices -- rounding-off -- a multiplier -- not but -- origin -- a ridgeline -- B -- rounding-off -- a multiplier (rounding-off multiplier of the middle point D of Ridgeline B) -- a certified value -- being low -- a value -- having set up -- a case -- **** -- a ridgeline -- B -- being concerned -- every -- four -- a side -- a form -- u -- ' -- v -- ' -- parameter value -- a low

value -- carrying out . Thereby, the ridgeline of the curved-surface model created by STEP1 approaches the ridgeline B of a corresponding grid model (grid polygon model), and the curved-surface model which sharpened rather than the case of a criterion and approached the grid polygon model is generated. Conversely, when the rounding-off multiplier of a ridgeline is set as a value higher than a certified value, a curved-surface model [far from a grid polygon model] roundish [wore more] is generated rather than the case of a criterion about the ridgeline.

[0039] (Example) what showed the surface model generated with this operation gestalt to drawing 9 (B) to the lattice model of the origin which rounded off to the grid polygon model shown in drawing 9 (A), and added information -- top-most vertices and/or a ridgeline -- being related -- a radius of circle -- or it becomes the configuration where **** was given. The configuration of drawing 9 (A) is generated by performing reverse rounding to the configuration corresponding to this drawing 9 (B). Moreover, output data can be extremely lessened by expressing the configuration of drawing 9 (A) in a XVL format.

[0040] Drawing 18 is drawing showing human being's model expressed in the XVL format, and the example of the shading display. Since XVL expressed by drawing 18 (A) is a light weight (this example 44 K bytes), it can be easily transmitted also by the network environment. Moreover, the surface model was generated from this lattice model, and drawing 18 (B) indicated this by shading. If this structure is mounted as a viewer, XVL on a network can be read and real 3D display can be performed. Moreover, if a surface model is generated from the configuration in XVL and the data for RP (Rapid Prototyping) equipments are outputted, a real model is generable as shown in drawing 19 . Moreover, if the data for CAM are generated from a surface model, such a real model is also processible.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the grid polygon model inputted.
[Drawing 2] It is drawing for explaining the method of generating the core of the field in a grid polygon model, and the middle point of a ridgeline.
[Drawing 3] It is drawing showing the example of quadrilateral division of a grid polygon model.
[Drawing 4] It is drawing for explaining the calculation approach of the core of the generated quadrilateral.
[Drawing 5] It is drawing for explaining the calculation approach of the top-most vertices of a curved-surface model.
[Drawing 6] It is drawing for explaining the calculation approach of the tangent of the ridgeline of a curved-surface model.
[Drawing 7] It is drawing for explaining the decision approach of a curved-surface model.
[Drawing 8] It is drawing for explaining the decision approach of control points P1 and P2.
[Drawing 9] ****** which shows the example of the curved-surface model generated by this invention.
[Drawing 10] It is a block diagram showing the functional configuration of the 1st operation gestalt of this invention.
[Drawing 11] It is drawing for explaining the flow of processing of the 1st operation gestalt of this invention.
[Drawing 12] It is drawing showing the example of a configuration in the case of carrying out this invention by the computer configuration.
[Drawing 13] It is drawing showing the DS of the data used by this invention.
[Drawing 14] It is drawing showing the outline of the 2nd operation gestalt of this invention.
[Drawing 15] It is drawing for explaining mounting of the processing in the 2nd operation gestalt of this invention.
[Drawing 16] It is drawing showing the DS of the configuration information by which endocyst is carried out to the XVL file in the 2nd operation gestalt of this invention.
[Drawing 17] It is drawing for explaining the decision approach of a rounding-off multiplier.
[Drawing 18] It is drawing showing human being's model expressed in the XVL format, and the example of the shading display.
[Drawing 19] It is drawing showing the example of generation of a real model.
[Description of Notations]
A [-- The middle point of a ridgeline, E / -- The generated quadrilateral,] -- A field, B, I -- A ridgeline, C -- The core of a field, D, Q, R F -- The computed core, G, G' -- The top-most vertices of the original grid polygon model, P0, P3 -- Top-most vertices of a curved-surface model, P1, P2 [-- Output means,] -- A control point, H -- The polygon, 1 which were generated -- An input means, 2 3 [-- A medium driving means 10 / -- Top-most-vertices calculation means,] -- CPU, 4 -- Memory, 5 -- A storage means, 6 20 [-- 43 A network, 44 / -- Client PC, 51 / -- A XVL input unit, 52 / -- A XVL inverter, 53 / -- XVL expansion equipment.] -- A ridgeline decision means, 30 -- A curved-surface generation means, 41 -- A server, 42

[Translation done.]

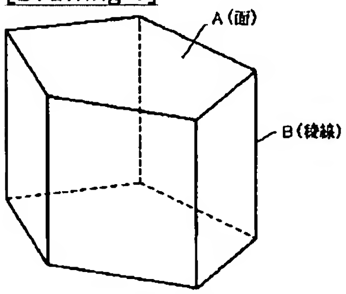
* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

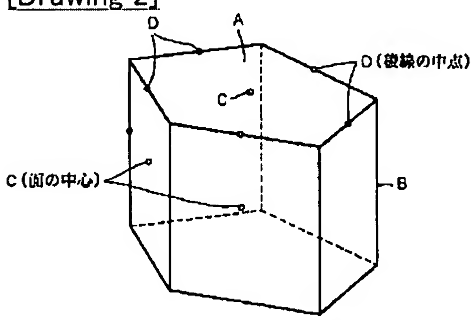
DRAWINGS

[Drawing 1]



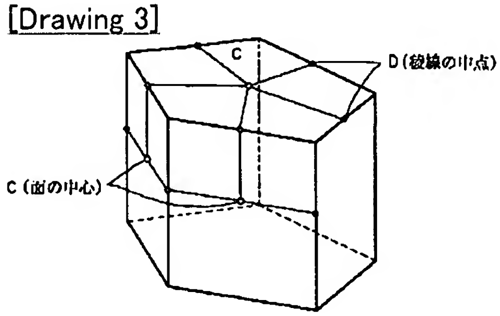
入力される格子ポリゴンモデル

[Drawing 2]



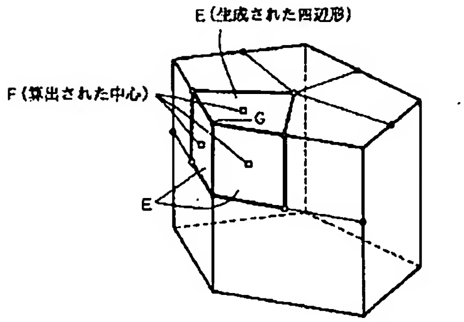
格子ポリゴンモデル内の面の中心と稜線の中点の生成

[Drawing 3]



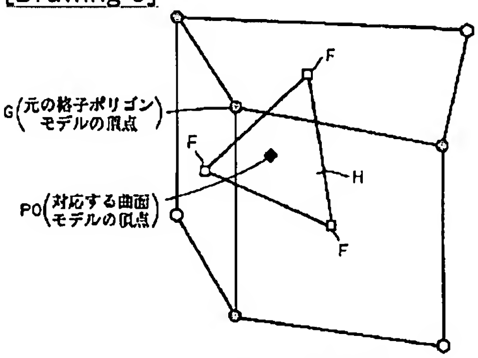
格子ポリゴンモデルの四辺形分割

[Drawing 4]



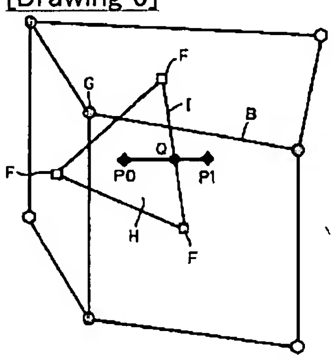
生成された四辺形の中心の算出

[Drawing 5]



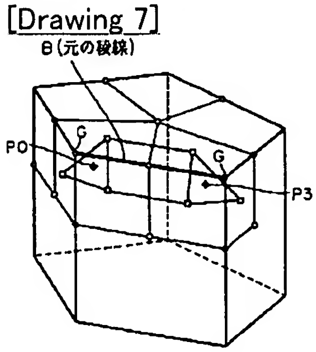
曲面モデルの頂点の算出

[Drawing 6]



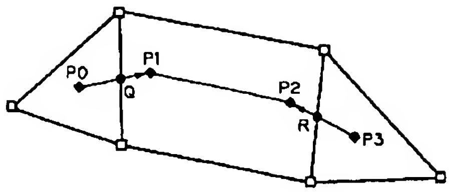
曲面モデルの稜線の接線の算出

[Drawing 7]



曲線モデルの決定

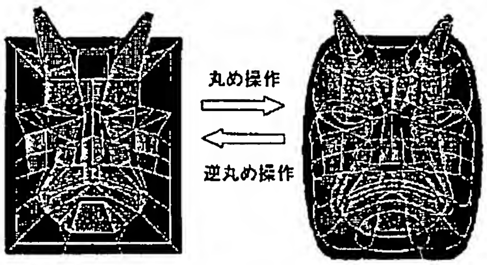
[Drawing 8]



制御点P1,P2の決定

[Drawing 9]

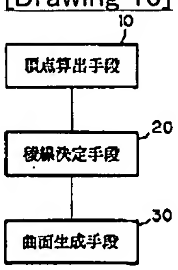
(A) (B)



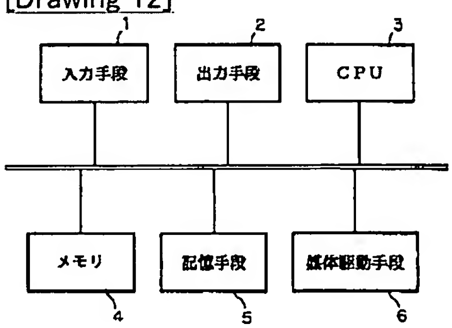
格子ポリゴンモデル　曲面モデル

本手法で生成された曲面モデルの例

[Drawing 10]



[Drawing 12]



[Drawing 11]

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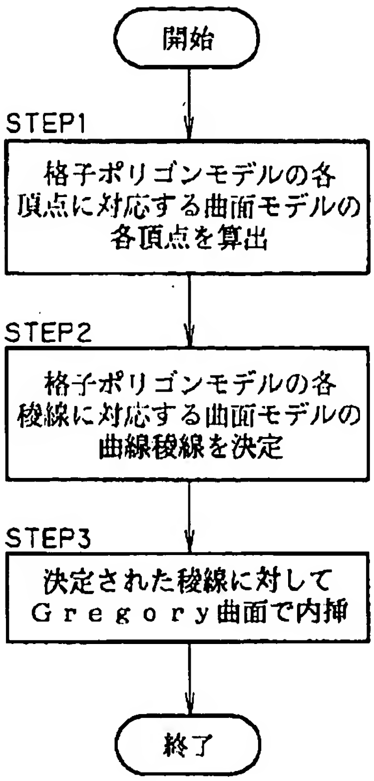


[Drawing 13]

(A) 頂点座標値テーブル200

インデックス値	格子ポリゴンモデルの(x,y,z)座標値	曲面モデルの(x,y,z)座標値
P0		
P1		
P2		
:		
Pn		

(B) 面インデックステーブル300

各行は頂点座標値テーブルへのインデックス値の列

P0	P1	P2		
P2	P1	P7	P5	
P5	P7	P3	P8	P4

(C) 稜線インデックステーブル400

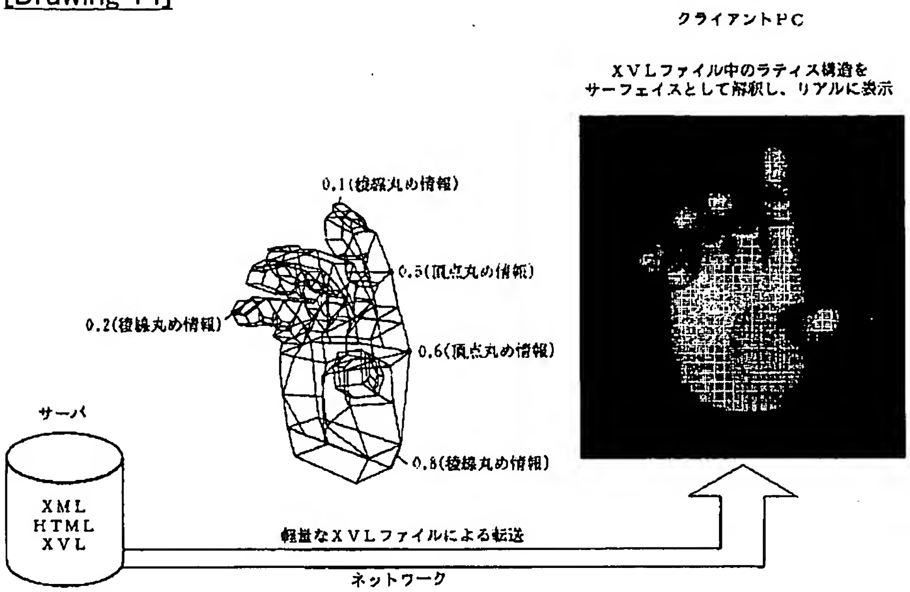
各行は頂点座標値テーブルへのインデックス値の列

始点	終点	制御点1	制御点2
P0	P1	C0	C1
P1	P2	C2	C3
P2	P3	C4	C5

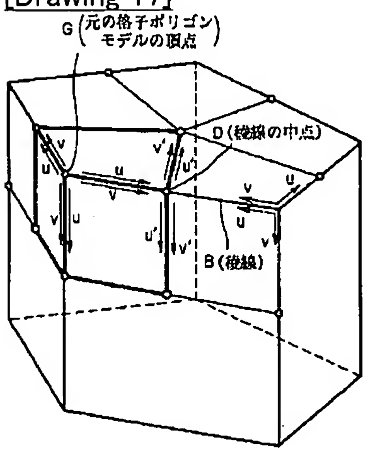
(D) 制御点座標値テーブル500

インデックス値	(x,y,z)座標値
C0	
C1	
C2	
:	
Ck	

[Drawing 14]



[Drawing 17]



丸め係数の決定

[Drawing 15]

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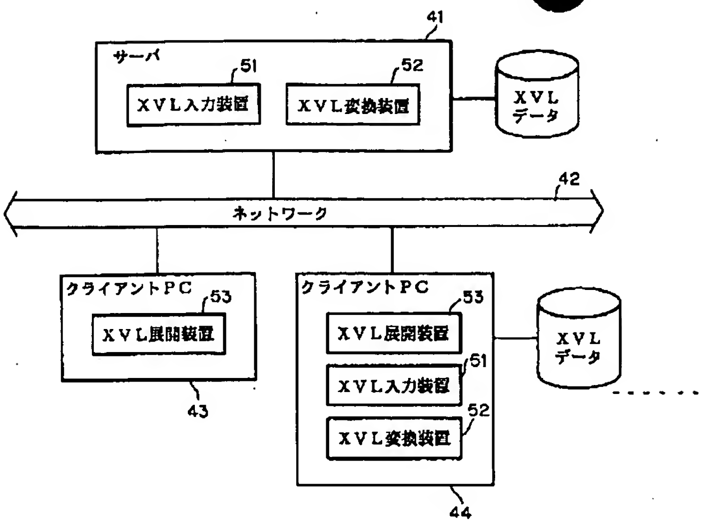
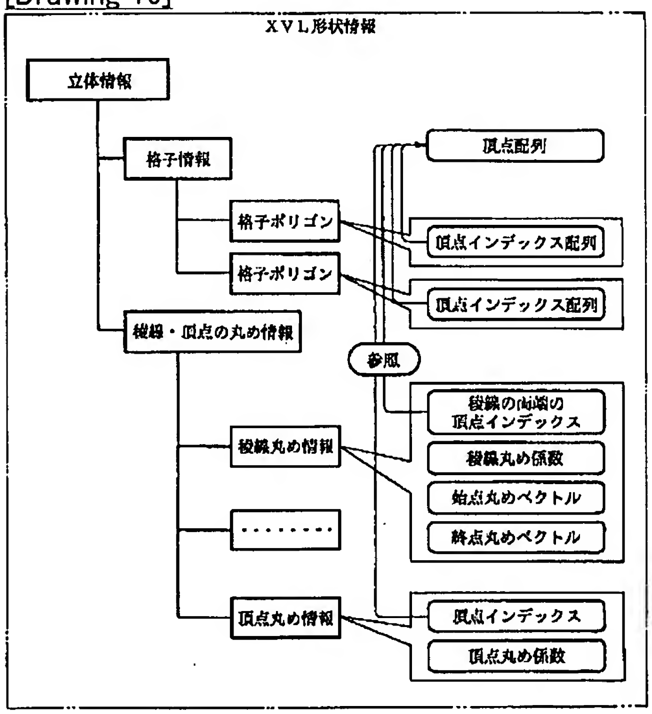
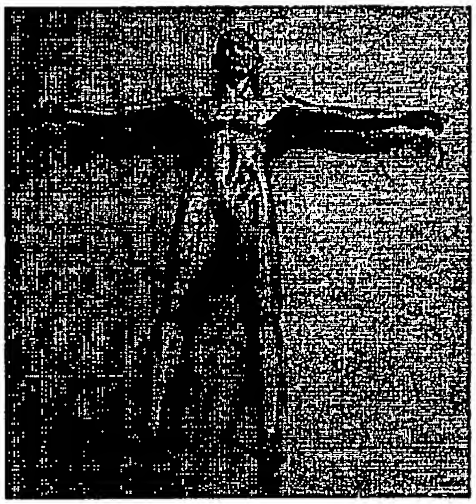


[Drawing 16]

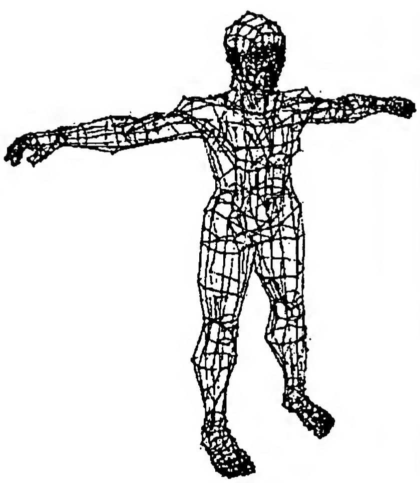


[Drawing 19]



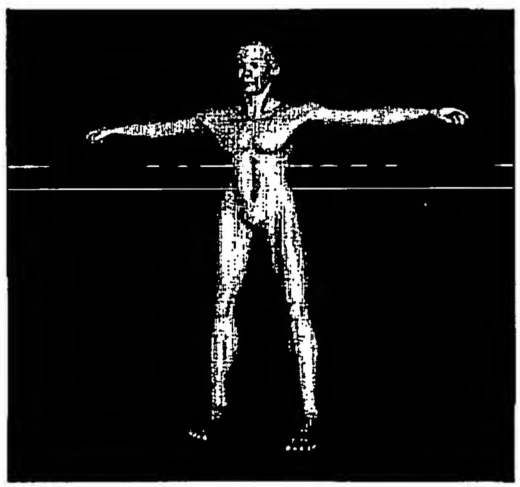
[Drawing 18]

(A)



ＸＶＬ表現：44K

(B)



サーフェイスデータのシェーディング

[Translation done.]